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Review of public–private partnerships in agro-energy districts in Southern Europe: The cases of Greece and Italy

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ABSTRACT

This paper presents a review of the methodology of implementing public–private partnerships (PPPs) for agro-energy districts in two rural areas in Southern Europe (the case of Greece and Italy). We propose a comprehensive methodology to apply a PPP scheme to agro-energy districts that includes guidelines for successful application of PPPs, the rationale behind them, the benefits for European rural areas, and the success and week factors in the implementation of PPPs. We also propose an initiative to adopt a PPP scheme for a specific agro-energy district and its preparation. The approach of the Greek case is a bottom-up application, which starts from the PPP scheme and then the target area is analysed; while the approach applied to the Italian case is a top-down application, starting from the target area and then, the right PPP scheme is established. We conclude that PPP schemes for agro-industry districts can successfully be implemented in rural areas either way for the production of thermal and electrical power from biomass residues.

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1. Introduction

The European Union (EU) faces serious energy challenges concerning sustainability, security of supply, import dependence and competitiveness as well as effective implementation of the internal energy market. According to the Commission [1] energy accounts for 80% of all green house gas (GHG) emissions in the EU and commitment is needed to address this by reducing them to a level that would limit the global temperature increase to 2 °C compared to pre-industrial levels. Most of EU27 countries reduced GHG emissions in 2011 [2]; Italy for example was at the top five members to contribute to this significant change between 2010 and 2011, whereas Greece was reported in the 13th place. A European Energy Policy is acknowledged as the most effective response to these challenges, which are faced by all member states. Within this framework of energy policy the creation of a high efficiency energy economy with low CO_2 emissions is realized by setting specific renewable energy targets: by 2020 renewable energy should account for 20% of the EU's final energy consumption, while in the 2005 it was only 8.5% [3]. Despite the fact that recent reports [2] note that GHG emissions are facing a major decline, the contribution of renewables to total final energy consumption has increased due to a higher decrease in fossil fuels consumption. It is also worth mentioning according to the same source [2] that biomass combustion increased by less than 1% in the EU-27 during 2011.

The EU Biomass Policy and Action Plan [4] states that biomass is essential for environmental and competitiveness reasons, while the European Parliament recently noted that "*biomass has many advantages over conventional energy sources, as well as over some other renewable energies, in particular, relatively low costs, less dependence on short-term weather changes, promotion of regional economic structures and provision of alternative sources of income for farmers*". Hence, it is high importance in rural areas and contribution to overall rural development [5].

Within this context of contemporary environmental concerns, economic restrains and discourses for new governance in rural areas emerges the concept of building partnerships between the public and the private sector for the purpose of delivering, in a more efficient way, a project or a service traditionally provided by the former [6,7]. This mixed partnerships, known as PPPs, recognize that both parties have strengths and resources in performing certain tasks and therefore one could benefit from different capabilities and levels of expertise. On the one hand, public bodies are encouraged to adopt PPPs as a tool for sustainable development in order to protect the public interest and serve citizens currently in demand for another type of governance aiming at both social and environmental sustainability. On the other hand, private bodies find within a PPP the opportunity to use their know-how, their abundant resources and gain profits under the condition that the take up all the risks [8–10]. The transfer of the risks of an investment to the private sector is considered one of the main benefits of a PPP in addition to the ability to secure additional financial resources or finance more projects as well as the enhancement of the investment in favourable accounting rules for the private sector [11].

When it comes to the environment, there is an inclination towards taking action and making agreements between public and private bodies in renewable energy [12]. Despite the fact that there are still constraints in the application of PPPs in agro-energy districts, PPPs can provide incentive and create comfortable ground for the development of an energy production plant and promote renewable energy through the use of biomass; reducing authorization, financing and contracting risks [13,14]. The global situation, as far as PPPs in energy sector concerns, is rather interesting. In fact many international organizations, like the Asian Development Bank [15] for example, seek to forge strong internal PPPs in the countries in which they operate, as they have tested that such partnerships provide a valuable bridge between the two sectors. In addition, a European Investment Bank evaluation report on PPP projects in different regions of the EU notes that PPPs tend to be characterized by professional project management and implementation, project delivery on time and on budget, an improved asset and service quality as well as a life-cycle approach defined performance standards throughout the contract period [16]. However, the problems in PPPs in developing countries are quite different than the ones raised in Europe.

This paper follows previous work done [17] under the project *RuralE*[1]. Within the framework of the project a methodology was used for a successful application of a PPP in regions of participating countries. In this paper we try to review the application of the methodology in two Southern European countries/regions: the region of Central Macedonia (in Greece) and in the region of Umbria (in Italy). We will focus on the ways and guidelines developed in order to facilitate through the PPPs the organization of the entire "bioenergetic chain" for sustainable energy production from biomasses in rural areas in both countries. Rural entrepreneurs, local authorities, energy field stakeholders are involved in a more suitable and efficient use of local resources, by using the PPP scheme.

2. Guidelines for successful application of PPPs in agro-energy districts

Agro-energy refers to the energy function of agriculture, which can make significant contributions to achieving social and environmental sustainability at local, national, regional and global levels. Using local resources (both agricultural and livestock) worldwide and various commercially available conversion technologies one could transform current traditional and low-tech uses of these resources to modern energies [18]. One of the first issues addressed within the project was the development of a proper definition of Agro-energy District (AeD). Despite the fact that the general concept is widely used, a clear formulation of the structure of AeD was still missing. The AeD can be differently understood, according to different experiences and needs in different areas. The definition adopted in this study stems from the work of Frayssignes [19] referring to a specific geographic area bringing together a large range of specialist SMEs and characterized by an "industrial atmosphere" founded on common values and an accumulation of skills through the search and transmission of knowledge. Examples of AeD are provided by the coupling of pyrolysis/gasification plants to a biodiesel or bioethanol production plant [20–23] or even to a vegetable oil extraction plant [24].

[1] The paper has been developed in the framework of the project "RuralE (Public-Private Partnerships for RES Agro-energy districts)" of the European programme Intelligent Energy. http://eaci-projects.eu/iee/page/Page.jsp?op=project_detail&prid=1838.

Table 1
Technologies employed in biomass CCHP.
Source: [25].

Primary technology	Secondary technology	Tertiary technology
Combustion producing steam, hot water	Steam engine; steam turbine; stirling engine; Organic Rankine Cycle (ORC)	Adsorption/absorption chillers
Gasification producing gaseous fuels	Internal combustion engine; micro-turbine; gas turbine; fuel cell	Adsorption/absorption chillers
Pyrolysis producing gaseous, liquid fuels	Internal combustion engine	Adsorption/absorption chillers
Biochemical/biological processes producing ethanol, biogas	Internal combustion engine	Adsorption/absorption chillers
Chemical/mechanical processes producing biodiesel	Internal combustion engine	Adsorption/absorption chillers

In AeD combined heat and power (CHP) generation has to be promoted, or even combined cool heat and power production (CCHP). The technologies used in biomass CHP are proposed in Table 1, taken from Ref. [25], adding cool production through adsorption chillers.

According to Maraver et al. [26] "absorption and adsorption chillers are thermally driven technologies, which are widely applied in CCHP systems". Bioenergy production technologies based on combustion have been interested by a satisfying development [27]; pyrolysis process simulation is improving [28–30] increasing plant performance [31]; low cost systems for tar reduction in producer gas are available [32]. An AeD represents a useful model for the achievement of important energetic and environmental goals in Europe and the world on the one hand whereas on the other is linked to rural development (competitiveness of rural areas, farmers' income, preservation of natural resources, reduction in climate change, social cohesion) [19].

A successful PPP in agroenergy district should fulfil three conditions at a minimum [33]: there should be benefits for private sector (e.g., generate a profitable revenue stream or expand market access); benefits for the consumer (e.g., delivery of services that people want and would not have access to at the same price in a business as usual situation, or. improvement of provided services); benefits for the government: fulfilment of a political need, social obligation, development imperative. A visual comparison of the success factors and weak factors in the implementation of PPPs are presented in the Appendix (see Fig. A1).

Among different types of renewable energy, only wind energy has achieved a rather advanced relationship between public and private [12]. This is because many times both partners (public and private) come to an agreement by which the municipality does not spend any money for the installation and moreover receive royalties according to the electricity sold, or discounts into the annual electrical bill. In relation to other types of renewable energy, the market is not yet matured as much as the wind one, where the investments are also quite high. Due to the EU policy regulation, the energy prices, and the territories sensitizing to the renewable energy and environmental benefits, more and more municipalities are taking action to improve energy efficiency and competences and also trying to increase the renewable energy use and exploitation into their territories, working together with the energy agency and not always influenced by the private sector.

During these last years, municipalities are better organizing themselves to take actions in the field of the renewable energies, making agreements with private enterprises, creating awareness to the citizens of the benefits related to renewable energies, involving town and citizen associations into common projects, cooperating with industrial associations and technology institutes for feasibility studies, trainings, and strategy decisions. Quite often, a renewable energy consortium is created when there is a clear and strong policy will to proceed in Municipalities. The first step is almost always the Mayor's decision supported by his advisors to take part into a renewable energy initiative, and implement changes and improvements into the municipality district. Onwards, the appropriate private companies (technology sellers, installers and maintenance) are contacted for a request for tender to next start up the project.

3. The preliminary stages of the implementation of a PPP

3.1. Identification of local needs

The first step in preparing a PPP is the selection of the area where the project will be developed in order to identify the desired coverage targets and service needs [33]. The party that conceived the idea for an AeD will have to carry out a sector analysis and define the technical specifications of the proposed PPP project. As a result of the sector analysis, the government is able to determine to what degree an enabling environment exists for PPP and what activities are required in advance of PPP to create such an environment. The diagnostic is important in order to: (i) identify the strengths and weaknesses of the sector and the most promising areas for efficiency increases, (ii) regularly gauge and report on the progress of reform, and (iii) tweak the reform program as needed. The sector analysis is likely to be performed with the support of a team of local and/or international engineers, lawyers, economists, financial analysts, energy and policy specialists, etc. The preparation stage is the time to develop the preliminary technical specifications. Development of the final technical specifications of a project is an iterative process, which builds on feedback from the market and the affordability of the project at each design stage. The technical design of a project starts with identification of desired coverage targets and service standards. From these starting points, estimating the cost of these desired services (factoring in presumed efficiency gains) and cost recovery tariffs is possible. In case of large project where high level governance is involved, there are the options of putting these cost recovery tariffs in place, subsidizing cost-recovery, or revisiting the initial targets and service standards. These preliminary specifications will ultimately be enshrined in the PPP contract dictating the technical outputs expected from the partnership. The technical preparation builds on (and refines) the analytical work that has been done in preparing the sector analysis.

3.2. Role of stakeholders

Despite the long experience with PPPs, they remain controversial among a range of stakeholders. This is partly due to the diverse range of stakeholders involved in the process and the difficulty in reconciling their interests and concerns. In addition, too often the stakeholders have not been properly consulted or engaged in the

Table 2
Role of different stakeholders in the PPP process [34].

Stakeholder	Role
Political decision makers	Establish and prioritize goals and objectives of PPP and communicate these to the public Approve decision criteria for selecting preferred PPP option Approve recommended PPP option Approve regulatory and legal frameworks
Company management and staff	Identify company-specific needs and goals of PPP Provide company-specific data Assist in marketing and due diligence process Implement change
Consumers	Communicate ability and willingness to pay for service Express priorities for quality and level of service Identify existing strengths and weaknesses in service
Investors	Provide feedback on attractiveness of various PPP options Follow rules and procedures of competitive bidding process Perform thorough due diligence resulting in competitive and realistic bidding
Strategic consultants	Provide unbiased evaluation of options for PPP Review existing framework and propose reforms Act as facilitator for cooperation among stakeholders

process. Consultation is increasingly seen as important for several reasons. First of all the inadequate consultation or communication with stakeholders increases the danger of opposition, potentially late in the process, leading to delays or even cancellation. Furthermore, the stakeholders are critical to the sustainability of a PPP. Even if the contract is awarded despite opposition, the difficulty and risk of the project increase drastically if public support is not present. Stakeholders provide valuable input to the design and practicality of an approach. Allowing stakeholders to comment on PPP strategies allows for a sense of buy-in and can lead to innovative approaches. Broad public support and understanding of the reform agenda encourage politicians to stay committed. Dissemination of information leads to increased credibility of project partners. Despite these compelling reasons, some public organizations see risk in public consultation either through the danger of raising expectations that may not be met, through losing control of the flow of information, through the danger of being unable to reconcile differences, or because information might fuel opposition. These risks are easily outweighed by the benefits of communication and the crucial role it plays in building support for, and understanding of, PPP. Each role is critical, yet specific stakeholders will have different interests that influence how they approach their role. There must be a consultation process to reconcile and prioritize issues, leading to broad agreement on the objectives of PPP. Table 2 lists the roles of the PPP process stakeholders.

4. Implementation of the provisional methodology in Greece

4.1. The stakeholders of the PPP

A PPP was planned in the region of Central Macedonia in Greece [35]. The target area is the prefecture of Kilkis and the area of Evropos Kilkis. The main PPP bodies involved are the Tobacco Cooperative of Evropos Kilkis, the Municipality of Evropos Kilkis and the private Company “Rodonas” located in the area. Moreover, Aristotle University of Thessaloniki was responsible for the technical support of this PPP, while a private company that designs and constructs industrial units for the energy utilization of biomass and solid waste was the technical expertise for the construction of the plant. Fig. 1 illustrates the stakeholders. The public is represented by the Municipality of Evropos, that will be the user of the energy (heat/electricity) produced, the biomass will be furnished by the cooperative of Evropos Kilkis. The energy conversion plant

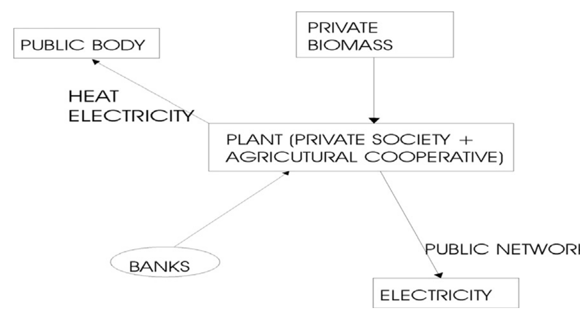

Fig. 1. PPP scheme description in Greece.

will be owned by the private investors and by the agricultural cooperative.

The basic roles in the PPP are distributed like this: the Tobacco Cooperative of Evropos Kilkis will provide the land and invest in the construction of the plant. It will motivate its members for the provision of biomass to the plant; the Municipality of Evropos will use the energy (heat/electricity) produced from the plant to cover the electricity and heating needs of its buildings; the company “Rodonas” Ltd. will provide raw material to the plant.

The tobacco co-operative of Evropos Kilkis is the longest -lived tobacco co-operative in the country. In 1987, they moved on to full reconversion of the tobacco growing by replacing the Kaba Kulak (classic) variety with the Virginia variety. At the same time, they created and operated a unit of 180 dryers under the supervision of the Co-operative's technical personnel. In 2005, the co-operative consisted of 180 members, with 4500 acres tobacco growing and a production of 1,348,000 kg of Virginia variety tobacco. In 2006, with the application of the new Common Agricultural Policy (CAP), almost all its members abandoned the Virginia tobacco growing and turned to the search of alternative cultivations.

Aiming to expand its members' plantations with high quality saplings at reasonable prices, the Co-operative was immediately engaged in producing multiplicative pomegranate matter. At the same time, and targeting the product's powerful and flexible access to the market, members of the co-operative created the company “Rodonas” Ltd., which now activates in every section of the production, processing, promotion and trading of pomegranate products in the local and international market. In cooperation with the company “Rodonas” Ltd., it supplies pomegranate plants to the co-operative as well as to anyone interested, under the regime of Agriculture by Contract. Today, over 150 producers, with over

2000 quarter acres pomegranate trees around the country are contracted.

The Municipality of Evropos is the public authority in the target area that is motivated to participate in the agro-energy PPP. Evropos is a municipality in the Paionia Province of Kilkis Prefecture in Central Macedonia, with a population of 6042 based on the 2001 census. The income of the majority of the population is based on agricultural activities. The greatest advantage of the area is the high percentage of irrigated land and the possibility to extend it with further land reclamation works.

One private investor, an SME interested to share the entrepreneurial risk together with the Municipality of Evropos is the company “Rodonas” Ltd. that was created in 2006 by members of the tobacco co-operative of Evropos of the Prefecture of Kilkis to reinforce the producers' personal responsibility in all collective activities that have to do with production, processing and trading of their products. The company's main guideline is a turn to products that are safe and beneficial (in addition to their alimentary value) for the consumer's health (functional food). Its goal is powerful and flexible access of these products to the local and international market. Today, in cooperation with the tobacco co-operative of Evropos Kilkis it activates in pomegranate growing under the regime of agriculture by contract.

4.2. Target area description

The prefecture of Kilkis is located in Central Macedonia Region in Northern Greece. Its capital is the city of Kilkis. It covers an area of 2519 km^2 with 86.086 inhabitants. The mountains near Kilkis are Paiko to the west, parts of the western part of Kerkini to the northeast and Krousia to the east. Lake Doirani is situated to the north and shares its eastern portion of the lake. The Prefecture of Kilkis has an agriculture-based economy with 45% of the active population involved in the primary sector of economy. Our main area of concern is the Municipality of Evropos, where the “Tobacco Cooperative of Evropos Kilkis” (TCTK) is based. Concerning employment, existing estimates suggest that the number of permanent employees has reduced by 50%, whilst the number of seasonal workers have been reduced from pre-reform levels of 7000 to about 2000. In 2006, with the application of new CAP the members of TCTK turned to the search and experimentation of other alternative cultivations. In this context and evaluating the trends of the European and global market, they have initiated the cultivation of pomegranate trees.

This choice was seen as an opportunity to maintain farmers' jobs and create a competitive rural economy that will be independent from subsidies and will eventually lead to sustainable agriculture and sustainable development of the Kilkis prefecture that currently possesses the last place in the development indicators (GDP etc.) and has been also included in the list of Greek areas with high risk of desertification due to intensive agriculture and soil degradation [36–39]. Enhancing the effort for the development of the area, we decided to study the scenario of using the agricultural residues of the area for the production of energy that could potential used for the needs of the cooperative (refrigeration of the fruits and the extracted juices) and the local energy needs of the Municipality of Evropos, while selling the excessive energy produced to the national grid. There seems to be a great potential for the use of the field crop residues. The general treatment in Greece is either to incorporate them into the soil or burn them in

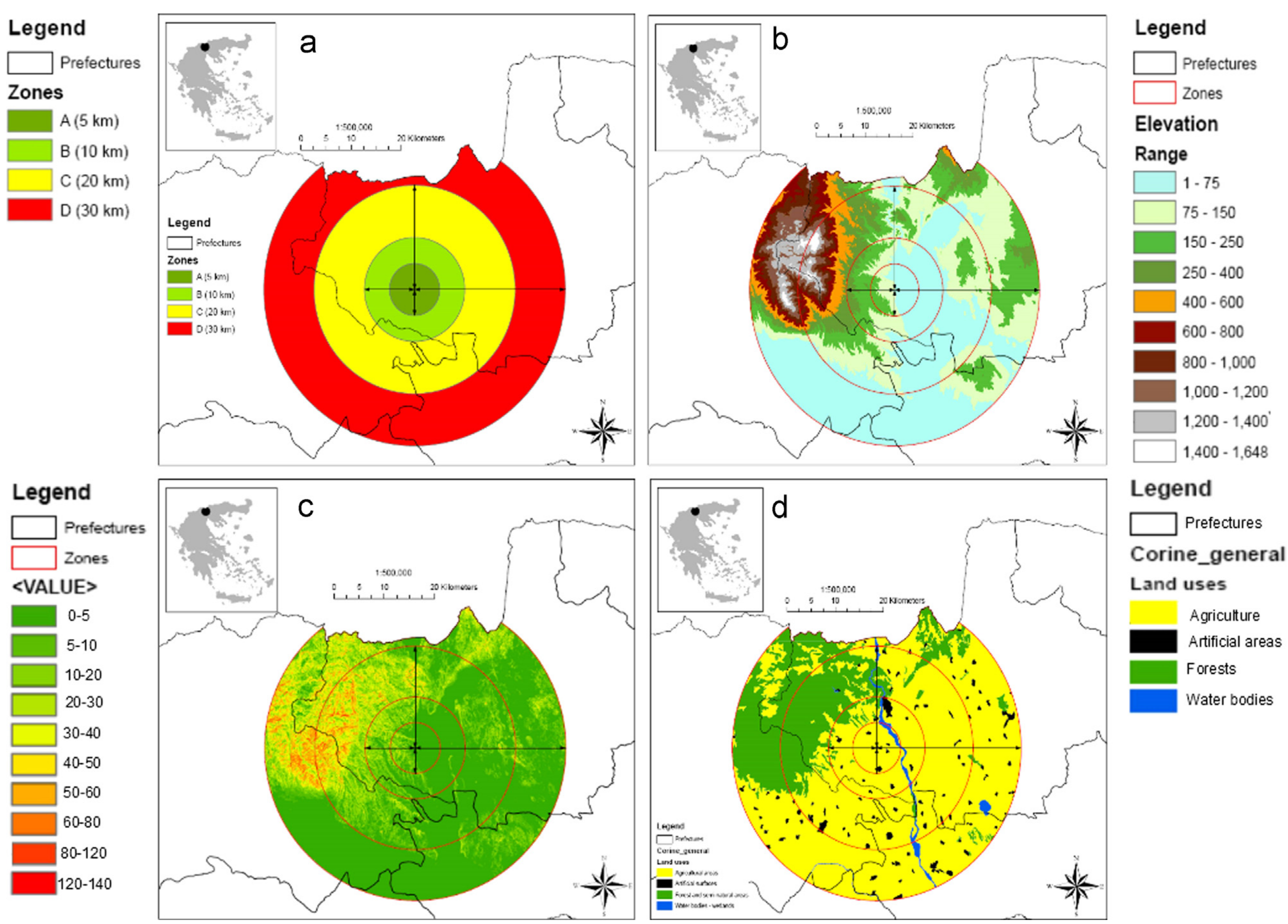

Fig. 2. Biomass production in target area.

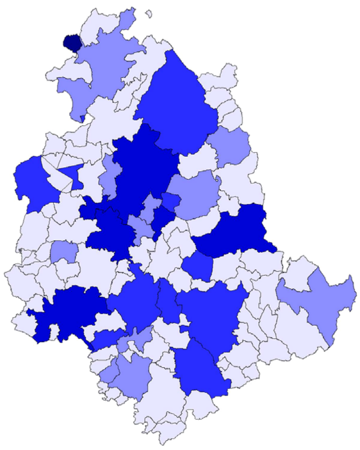

Fig. 3. Liquid biomass production in Umbria region.

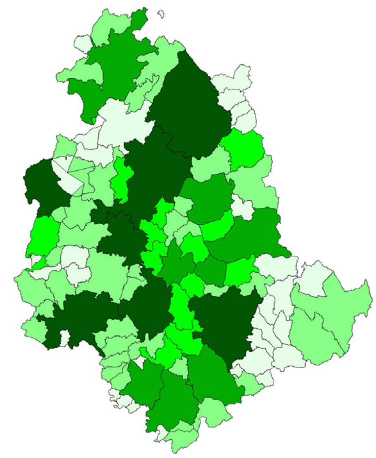

Fig. 4. Solid (dry) biomass production in Umbria region.

the field. A part is already exploited and used in several energy and non-energy markets. Cereal straw is used for various purposes such as animal feeding and animal bedding; in some cases also used for heat production in greenhouses. There are no alternative markets for cotton, corn stalks and corncobs but difficulties in harvesting and handling. Olive prunings (especially the large stems) are used in stoves and chimneys for residential heating.

4.3. Area characteristics for biomass production exploitation

The target area characteristics for biomass production are shown in Fig. 2, such as: the zones of influence for biomass production, area coverage per each zone, the main land uses, the net agricultural land and its distribution to zones. Agricultural land was computed at 1907.8 km^2 using Corine Land Cover. The net agricultural area was computed by neglecting pastures (5460.7 ha according to corine) and a 40% of the remaining land, which was attributed to roads and buffer zones (it was determined using sampling sites using orthophotos) Figs. 3 and 4.

According to coefficients published literature and a study of the ENEA[2] referred to Greek and Italian conditions [40–42], biomass production (tones) per zone and per crop was determined and is given in Table 3. Total biomass production from all crops in the target area is estimated to 188,540.1 ton.

Once biomass production in the region has been estimated the collectable biomass has been calculated using coefficient of availability (ca), taken from the study of Papadopoulos and others [43]

$$\text{ca} = \text{available residue}/\text{total residue} \tag{1}$$

4.4. Heat and electricity production using biomass

Once the available biomass has been calculated to estimate the obtainable heat and electricity available energy and power is not immediate. Several studies of "biomass energy surveying" in selected areas have been realized and a summary of them are proposed in Appendix, see Tables A1 and B1, a summary of key technological parameters of biomass CHP or CCHP systems are presented, taking into account that, once the efficiency of a plant are known, a complete review on biomass conversion system design is presented by Yilmaz and others [44]. Using the LHV values for each crop from Refs. [41, 42, 44, 45], heat and electricity

[2] Italian National Agency for New Technologies, Energy and Sustainable Economic Development, http://old.enea.it/com/ingl/.

Table 3
Biomass production (ton) per crop and per zone.

Crop	Zone				Total biomass	Total available biomass
	A	B	C	D		
Pomegranate	195.5	102.3	68.6	35.6	402.0	201
Cherry trees	81.5	34.1	102.8	213.4	431.8	259.08
Vineyards	36.3	103.9	328.9	495.8	964.9	482.45
Tobacco	5.2	4.3	22.5	34.0	66.0	46.2
Rice	0.0	0.0	0.0	5264.2	5264.2	2632.1
Sunflower	4.6	13.2	41.8	63.0	122.6	85.82
Cotton	830.8	2380.2	7534.5	11,358.3	22,103.8	15472.66
Hard wheat	4305.9	12,331.4	39,038.7	58,845.5	114,521.5	28630.38
Maize (stalks)	936.0	2681.7	8489.0	12,797.1	24,903.8	12451.9
Maize (cobs)	180.0	515.7	1632.5	2461.0	4789.2	2394.6
Oat	4.2	12.1	38.2	57.5	111.9	55.95
Barley	348.5	998.3	3160.2	4764.0	9271.1	4635.55
Rye	192.3	551.0	1744.3	2629.5	5117.1	2558.55
Olives	17.7	50.6	160.3	241.7	470.3	235.15
Sum	7138.6	19,778.8	62,362.3	99,260.5	188,540.1	70,141.39

production using biomass was determined. Heat and electrical energy was determined using the following equations.

$$\text{Heat production (MJ)} = 0.9 \times \text{Biomass (kg)} \times \text{LHV (MJ/kg)} \tag{2}$$

Assuming that boiler efficiency is 90%, based on the experience gained at the Italian Biomass Research Centre Laboratories, that host a biomass boilers certification test bench.

$$\text{Electricity production (MJ)} = 0.2 \times \text{Biomass (kg)} \times \text{LHV (MJ/kg)} \tag{3}$$

Assuming that power plant efficiency is 20% based on the data reported in Refs. [44,45].

Power efficiency and boiler efficiency were assumed also based on the data presented in Table 4. Besides assuming that electricity is produced in CHP systems, we have added also the heat produced in cogeneration, calculated with the following formula:

$$\text{Cogeneration heat (MJ)} = 0.6 \times \text{Biomass (kg)} \times \text{LHV (MJ/kg)} \tag{4}$$

The corresponding heat and electrical production are given in Table 4, evaluating two cases: the case of only heat production and the case of electricity production through cogeneration. Considering that thermal power is used for 2000 h per year of operating time, and electrical power for 7000 h per year of operating time,

Table 4
Thermal power (MW) and electric power that can be installed in the studied area.

Crop	Only heat production	Electricity and heat production in a CHP system	
	Thermal power (MW)	Electric power (MW)	Heat produced in CHP
Pomegranate	0.55	0.04	0.11
Cherry trees	0.71	0.05	0.14
Vineyards	1.33	0.08	0.25
Tobacco	0.09	0.01	0.02
Rice	4.94	0.31	0.94
Sunflower	0.18	0.01	0.04
Cotton	34.81	2.21	6.63
Hard wheat	57.26	3.64	10.91
Maize (stalks)	24.90	1.58	4.74
Maize (cobs)	5.39	0.34	1.03
Oat	0.12	0.01	0.02
Barley	9.85	0.63	1.88
Rye	5.44	0.35	1.04
Olives	0.65	0.04	0.12
Sum	146.22	9.28	27.85

the conversion to MW power production was performed. Table 4 improves the data already presented in Ref. [17].

5. Implementation of the provisional methodology in Italy

5.1. Umbria region characterization

Biomass assessment in Umbria region was based on the methodology developed by Rosillo-Calle in the Biomass Assessment Handbook [46] and on the researches developed by the Italian Biomass Research Centre [47–50]. Other studies available in Literature have been consulted (see Appendix Table C1), comprised the results of three European projects: BEE [51], CEUBIOM [52] and BEN [53].

Agroforestry biomasses in Umbria Region can be classified in different typologies: agricultural residues (straw, prunings, animal husbandry residues etc.); forestry biomass; animal husbandry residues; wine, olive oil and dairy industry residues. The availability has been calculated for every municipality inside the region, because the municipality is the ideal basin to achieve a short bioenergy production chain in a distributed energy conversion system. The methodology approach was different depending on the typology of biomass analysed. For the estimate of forestry biomass production the regional forestry inventory (IFRUM) and the regional forestry map can be used as base data. The methodology followed consists of different steps: assignment of yearly mean increment to each forestal species (using data taken form IFRUM); individuation of the different surfaces present in Umbria Region for each forestal species (using data contained in the Forestry Map); individuation of the yearly harvestable surface for each forestal species; calculation of the potential harvestable biomass and comparison with effectively harvested according to National Statistic Institute (ISTAT) data. With regard to agricultural residues the adopted methodology is that explained in Ref. [40], that is: cultivated surfaces evaluation; residue production per unit of cultivated area estimate; calculation of the total production for the different kinds of residues. For the estimate of animal husbandry residues the following methodology was used: at first the number of animals was considered for each species; then coefficients available in the literature were used to evaluate effluent production per animal; the calculation of animal residue production was done multiplying production for the number of animals. Estimates about agroindustry wastes have been done dividing the sector in the following categories: wine industry; olive oil industry; dairy-farming industry. For each of these categories the total residues production was evaluated mainly through questionnaires proposed to different producers and to public agencies that deal with residue displacement. For olive husk the data were furnished by Agecontrol (national agency for olive oil control) and Umbria Region. Exhausted oils are estimated using a coefficient cited in Ref. [54]. Whey production and slaughter residues were declared by Local Health Agency (ASL). Wine industry residues data were declared by a local distillery that collects vinasse from all the regions. Regional agroforestry biomass availability can be divided in 4 categories: hearbaceous residues; woody residues; forestry biomass; animal husbandry residues; food industry residues. In Table 5 main results are presented and discussed.

Table 5
Biomass availability in Umbria Region.

Typology	Availability (dry kTon/year)	Availability (liquid kTon/year)
Straw	368.1	
Stalks and leaves, soybean, sunflower, other	119.2	
Leaves and collar, sugar beet	21.0	
Stalks and leaves, potato, tobacco, tomato, others	7.9	
Vineyard prunings	29.9	
Olive grove prunings	36.9	
Fruit tree prunings	2.6	
High forest	75.153	
Simple coppice	179.717	
Complex coppice	55.808	
Out of forest	9.565	
Pigs		730
Cattle		460
Ovines and capridae		219
Chicken		298
Olive oil industry, olive husk	10	
Olive oil industry, waste water		13
Olive oil industry, stone (pits)	1	
Wine industry	4	
Slaughter residues		1123

Both herbaceous residues and woody residues belong to agricultural residues. These are different from forestry biomasses that are produced by woodlands that in Umbria Region are mostly represented by coppices. Forestry biomass is mostly used for household heating in traditional devices (i.e. fireplaces). By the point of view of energy conversion the different typologies of biomasses can be classified in solid biomasses (straw, prunings, forestry biomasses, olive husk, vinasse etc.) and liquid biomasses

(vegetable water, animal husbandry wastes etc.). Dedicated crops can be divided into humid crops and dry crops (poplar, black locust, miscanthus, cardoon etc.). Solid biomasses and dry crops can be used to produce heat or in cogeneration with Rankine cycles, gasification and pyrolysis technologies. Liquid biomasses and moist crops can be used to produce biogas for CHP applications.

5.2. Municipality choice

After analysing the total availability of biomass in Umbria region the choice of the municipality interested to implement the PPP case study was done based on: biomass availability itself, the existing bioenergy plants (Fig. 5) and the availability of stakeholders.

The chosen municipality of Montefalco is situated in a panoramic position, dominating the plain of the rivers Topino and Clitunno. For this favourable position is called “The railing of Umbria.” It is a municipality with 5761 inhabitants and it is situated in the province of Perugia. It is a reference point for the wine industry of the region and has among its main productions: the Sagrantino of Montefalco and Rosso of Montefalco. The main crops herbaceous crops cultivated are: maize and wheat. The woody species cultivated are: olive trees and vineyards. In the target area also swine breeding and cattle breeding is practiced. Other important activities are agritourism and artigianal activities. Montefalco Municipality main characteristics are shown in Table 6.

The vineyards in the target area are about 600 ha and they produce about 2 t/ha. These could be used to produce heat in a biomass boiler. The agroenergy chain concerns the realization of a plant for energy recovery of vineyards pruning residues and it is divided into different phases: harvesting and storage by round-baler, chipping cylindrical bales to obtain bio-chips, whose size is consistent with the biomass boiler, chemical-physical characterization of biochips and energy conversion phase. The vineyard pruning production has been estimated to be around 1000 t/year. This could provide a heating power of about 2 MWth. Assuming that it could not be possible to harvest completely all the biomass the stimated feasible capacity of the plant would be 0.4 MWth. This could be used to provide heat to big energy sinks as hospitals or schools or sport centres etc. The round balers are simple to charge and manage as material. Many of the agricultural entrepreneurs can store and manage the raw material. The technology used will be 0.4 MWth moving grate biomass chips boiler, designed for woodchips. In order to create a consistent supply chain it is necessary to stipulate supply contracts among local farmers and public authority. The biomass assessment results for Montefalco are shown in Table 7.

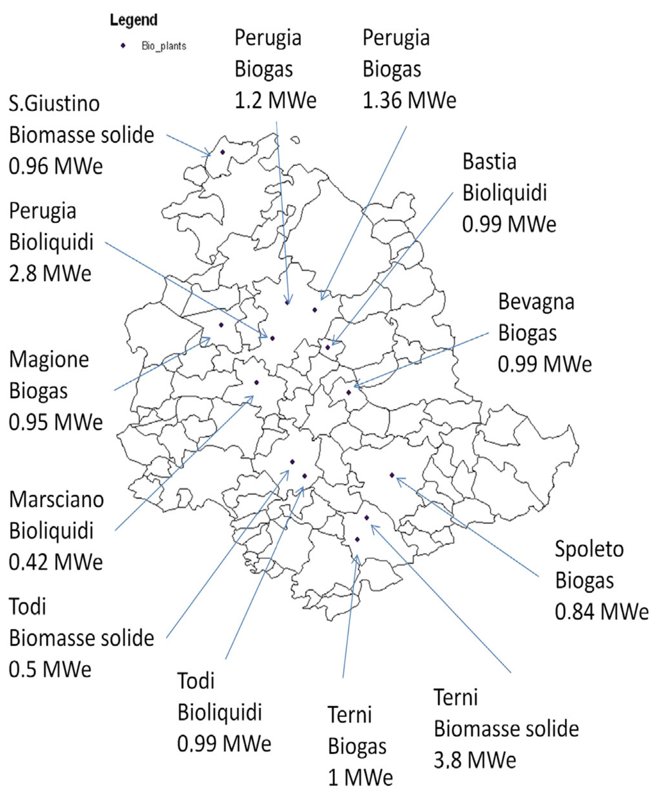

Fig. 5. Bioenergy plants present in Umbria region.

Table 6
Montefalco Municipality characteristics.

Inhabitants	5761
Number of cities/towns/villages	1/–/–
Population density (no./km^2)	81.2
Surface (km^2)	69.31

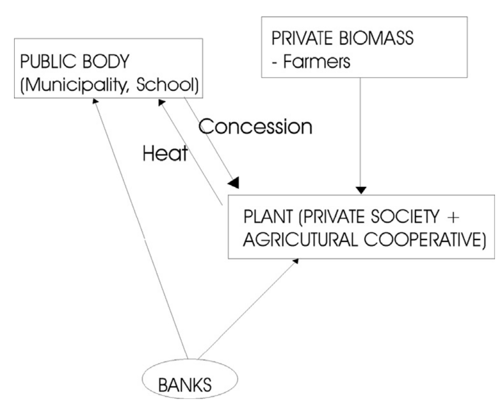

Fig. 6. PPP scheme for Italy.

Table 7
Biomass assessment.

Type of biomass	Quantity produced in the target area (ton)	Thermal power (MW)	Power available in the target area MW	Heat produced in cogeneration (MW)	Energy scenario
Wheat	5202	7.5	–	–	Heat
Maize	3486	5.2	–	–	Heat
Olive trees	1697	–	0.3	0.6	CHP
Olive husk	7760	–	0.8	1.6	CHP
Vineyards	1201	–	2	–	Heat
Pig manure	26475	–	0.4	0.8	CHP
Cattle manure	11370	–	0.2	0.4	CHP

5.3. Determination of the PPP scheme

The actors of the selected agro-energy district are grouped in: farmers; municipality personal; banks; biomass conversion plant seller; and energy service company. The subjects of the district will interact mainly through contracts, that is: land contract; fuel contract; plant contract; operation and maintenance contract; heat contract. Once the target area characterization is completed and the key actors and partner search are terminated, the PPP scheme is so determined (see Fig. 6).

The Public Body (Municipality of Montefalco) will make a public call for a concession to realize a 0.4 MWth biomass heating plant. The plant will be realized by a private partner and the biomass will be produced by private partners. The heat obtained from biomass conversion will be sold to a public school. The banks can be used to finance both the public and the private partner.

6. Conclusions

The paper sought to review useful guidelines as proposed for a successful application of PPPs in agro-energy districts, along with the rationale of PPPs, the benefits for European rural areas, and the success and week factors in the implementation of PPPs. Two initiatives to adopt a PPP scheme for a specific agro-energy district and the preparation of a PPP are also proposed. The implementation of a PPP in Northern Greece for the production of electrical and thermal power is further presented. The total thermal and electrical power that can be produced from the biomass of residues of all crops in the target area are estimated to 146.22 MW and 9.28 MW per year respectively. The main PPP actors are a local tobacco Cooperative, a Municipality and a private company whereas other institutions and companies will be responsible for the technical and financial support of this PPP. The application shows that the PPPs schemes can successfully be implemented in rural areas and set up agro-industry districts for the production of electrical and thermal energy.

A PPP case study applied to an Italian municipality is also presented. The municipality of Montefalco is situated in a panoramic position, dominating the plain of the rivers Topino and Clitunno. For this favourable position is called "The railing of Umbria.". It is a reference point for the wine industry of the region. The actors of the selected agro-energy district are grouped in: farmers; municipality personal; banks; biomass conversion plant seller; energy service company. The subjects of the district will interact mainly through contracts. The Public Body (Municipality of Montefalco) will make a public call for a concession to realize a 0.4 MWth biomass heating plant. The plant will be realized by a private partner and biomass will be produced by private partners. The heat obtained from biomass conversion will be sold to a public school. The banks can be used to finance both the public and the private partner.

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Appendix A

See Fig. A1 and Table A1.

Success factors	Weak factors
1) Private sector is in general a better manager	a) Lack of competition might create an inefficient structure
2) Private partners bring more innovation capacity	b) Blurriness in the partners selection procedure can jeopardise the venture
3) Social character of the PPP	/
4) The partnership structure is essential	c) Usually there is loss of control by the public sector
5) Dedication and cooperation among the parties	d) Often partners have different expectations and understanding of their roles
6) The re-structuring of the partnership is easier	/
7) The PPP project can be easily replicated	e) Further specifications especially for energy are necessary.
8) Experience and lessons learned abroad are useful	/
9) For some countries, like Greece EU regulations on state deficit promote PPPs.	f) PPP in Greece and other countries are "accused" of disguised privatisation. g) PPP are seen as "easy solutions" or a "sell-out of the country"
10) A successful PPP project leads to other initiatives	/
11) A strong insurance policy a risk mitigation plan is essential for the private partner	/
12) Knowledge Transfer is fundamental	/
13) A solid and simple to follow legislative framework is necessary.	h) The process of PPP implementation is long and bureaucratic
14) Existence of PPP units at government level, that provide guidance	i) Lack of experience in the administration of the public units
15) Community acceptance is important	/
16) Political backing is important	j) The lack of politic support can influence negatively
17) Energy PPPs make extensive use of local resources	
18) Jobs are created	/
19) The relationship between investment and pricing is an important factor.	/
20) The level of resources available in the system is important	k) The supply of biomass has to be ensured in a long-term period

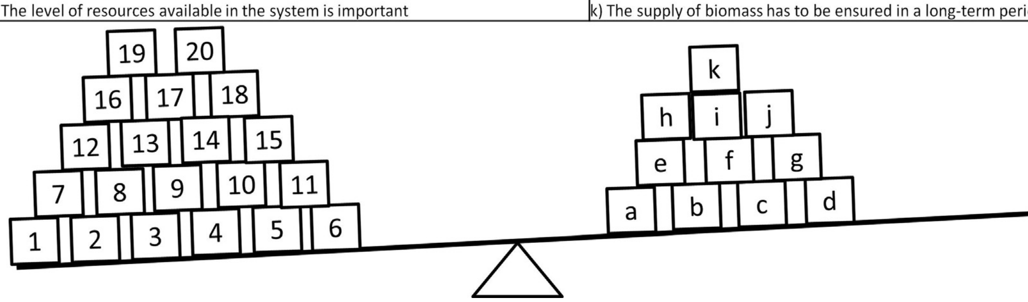

Fig. A1. Success factors and weak factors in PPP implementation.
Source: [7,33].

Table A1
Methodologies applied in bioenergy potential surveying studies.

Biomass energy surveying studies – Reference	Methodology applied
Papadopoulos et al. [40]	1. Biomass potential assessment (considering areas interested, yearly residual biomass production coefficients, standard deviation on productivity) 2. Practically available biomass assessment (using availability coefficients) 3. Assessment of the expected energy/power potential (assuming technical data of the CHP unit) 4. Economical analysis (assuming economical data of the CHP unit)
Manos et al. [17]	1. Interested areas estimation (using GIS data) 2. Biomass potential assessment (considering the area interested and residual biomass production coefficients) 3. Energy potential evaluation (multiplying biomass production for its energy content) 4. Power potential evaluation (considering plant efficiencies, heat and power production, yearly working hours of the bioenergy plant)
Meehan and McDonnell [55]	1. Identification of the suitable area for energy crops production 2. Dedicated biomass production potential evaluation 3. Residual biomass production potential evaluation 3. Total energy evaluation (multiplying biomass production for its energy content)
Jingjing et al. [56]	1. Estimation of biomass and animal husbandry effluents 2. Estimation of biogas yields obtainable from residual biomasses
Zheng et al. [57]	1. Data of total crop grain yields, cattle capita and biogas digesters are collected from the statistic data of the local government. 2 Crop residues are recalculated on the base of original crop grain yields data. 3 The crop yields are transformed into crop residue values and recalculated, with the mean universal values being gained. 4. Biogas potential production is evaluated experimentally
Zeng et al. [58]	1. Tons of straw produced per crop in China are calculated 2. Consumption percentage identification 3. Energy production evaluation, expressed in tons of coal equivalent (tce)
Yanli et al. [59]	1. Evaluation of biomass produced 2. Evaluation of heat production (considering the efficiency of boilers) 3. Evaluation of power production (considering the efficiency of power generation from biomass)
Mohammed et al. [60]	1. Residual biomass evaluation (using coefficients) 2. Energy potential evaluation (considering biomass energy content)

Appendix B

See Table B1.

Table B1
Biomass CHP systems characteristics.

Biomass CHP system analysis – Reference	Technology	Power range	Electrical efficiency (%)	Global efficiency (%)
Maraver et al. [26]	Stirling engine	1–150 kWe	15–35	65–85
	ORC cycle	3–2000 kWe	8–23	60–80
Ren et al. [61]	CCHP system based on anaerobic digestion	/	32	84
Henderick and Williams [62]	CCHP system based on gasification	75 kWe	15	~54
Dong et al. [25]	Externally fired microturbine	100 kWe	17	80–85
Börjesson and Ahlgren [63]	Condensing steam turbine	10–30–80 MWe	27–30–34	110
	Biomass integrated gasification combined cycle (BIGCC)	10–100 MWe	43	90
Salomón et al. [64]	Steam turbine	0.5–100 MWe	20–30	85–93
	Steam engine	0.02–5 MWe	6–20	85–95
	Microturbines	0.025–0.5 MWe	11–33	70–90
	Air bottoming cycle	0.1–250 MWe	30–44	~80
	Evaporative gas turbine	5–25 MWe	~55	~94

Appendix C

See Table C1.

Table C1
Biomass assessment consulted studies.

Biomass typology	Production coefficients reported (t/ha)
Pomegranate [17]	1.2
Cherry trees [17]	1.5
Vineyards for fresh fruit production [17]	
High trellis (Y shape)	2.6
Standard trellis	1.9–2.9
Horizontal trellis	5.0-3.1
Vineyard for wine production [65]	
Vase shape	0.9–3.9
Standard trellis	1.1–3.2
Tobacco [17]	0.3
Rice [17]	2.9
Sunflower [17]	2.4
Cotton [17]	2.5
Hard Wheat [17]	1.4
Maize [17]	3.6
Oat [17]	1.2
Barley [17]	2.3
Rye [17]	1.5
Olive tree [66]	
Annual pruning	1.0–2.8
Biennial pruning	1.3–4.6
Almond tree [67]	0.3–2.8

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